

PA.4 Fireside Issues Associated with Coal-Biomass Cofiring

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Abstract

Concerns regarding the potential environmental impact of fossil fuel use for power generation and other energy supplies are increasing in the US and abroad. One resolution of these concerns is to increase the fraction of renewable fuel in the national energy budget. Historically, renewable energy sources have struggled to compete in open markets with fossil energy. Cofiring biomass with coal in existing pulverized-coal boilers offer the potential for overcoming this problem by capitalizing on the large investment and infrastructure associated with existing fossil-fuel-based power systems. Cofiring offers the potential for reduced traditional pollutant (SO_x and NO_x) and net greenhouse gas (CO_2) emissions. In addition, the efficiency of power generation from cofired biomass is much greater than existing and many future standalone biomass power systems. Ancillary benefits include increased use of local resources for power, decreased demand for disposal of residues, and continued use of the large, reliable, and proven coal-based capacity that is the current backbone of the US power system. These advantages can be realized in the very near future with very low technical risk. However, improper choices of fuel, boiler design, or operating conditions could minimize or even negate many of these advantages while putting the boiler at risk.

This poster examines fireside issues associated with coal-biomass cofiring. The biofuels investigated range from woody (lignaceous) to grassy and straw (herbaceous) materials. These fuels are blended with common utility coals and fired in a pilot-scale facility. Measurements of NO_x emissions, ash deposition rate, carbon conversion, and corrosion potential form the basis for guidelines to assist in the implementation of cofiring at commercial scale.

Experimental characterization of NO_x emissions from neat coal and neat biomass combustion illustrate that NO_x emissions from biomass can either exceed or be less than those of coal. NO_x emissions from blends of coal and biomass interpolate quite accurately between the measured behaviors of the neat coal and biomass fuels if no attempt is made to optimize the aerodynamics or flame structure. The guidelines derivable from this work relative to NO_x emissions include: (1) there is insignificant chemical interaction between the offgases from biomass and coal that would alter NO_x emissions; (2) NO_x emissions from the most well-suited biomass fuels for cofiring (wood residues) generally are lower than those from coal, leading to some overall NO_x reduction relative to coal during cofiring; and (3) the large volatile yield from biomass can be used

to advantage to lower NO_x emissions during cofiring through well-established, stoichiometric-driven means.

Ash deposition rates from biomass fuels can greatly exceed or be considerably less than that of coal. Absolute deposition rates from some herbaceous fuels exceed that of coal by about an order of magnitude whereas deposition rates for high-quality woods are nearly an order of magnitude less than that of coal. Deposition rates from blends of coal and biomass lie between the observed rates for the neat fuels but are generally less than one would expect if interpolating between the behavior of neat fuels. Experimental evidence supports the hypothesis that this reduction in deposition rate occurs primarily because of interactions between alkali (mainly potassium) from the biomass and sulfur from the coal. The guidelines relative to ash deposition include: (1) deposition rates should decline when cofiring wood or similar low-ash, low-alkali, low-chlorine fuels; (2) deposition rates should increase when cofiring high-chlorine, high-alkali, high-ash fuels, such as many herbaceous materials; (3) deposition rates depend strongly on both individual fuel properties and interactions between the cofired fuels.

The large size of biomass particles relative to pulverized coal raises concerns regarding overall levels of unburned carbon. Experimental data indicate that biomass chars burn under strongly diffusion controlled conditions, as is consistent with theory. However, the rates of combustion differ from that of coal owing to its generally nonspherical shape and lower char density. The guidelines relative to carbon conversion derivable from this work include: (1) particles should be prepared with top sizes of about 3 mm (1/8 inch) to completely burnout, with significant residual carbon expected at sizes greater than 6 mm (1/4 inch) as measured from by the smallest dimension in the typically non-equant particles; (2) moisture contents should not exceed 35%, with higher moisture fuels requiring smaller particle sizes; and (3) biomass char burning rates are controlled by geometry and size, not kinetics, making burning rates essentially fuel independent if size, shape, density and moisture contents are the same.

The high chlorine and alkali contents of some biomass fuels raise concerns regarding corrosion. The greatest concern is high-temperature corrosion of superheater tubes induced by chlorine on the tube surface. This investigation indicates that chlorine can selectively deposit on heat transfer surfaces, which is consistent with a proposed mechanism of alkali chloride condensation. More significantly, the amount of chlorine in the deposit decreases sharply with increasing sulfur content. The stoichiometry of the overall chemical reaction between alkali chloride and sulfur is described by a parameter which characterizes the potential chlorine concentration in a deposit. This parameter provides a quantitative guideline for preventing chlorine deposition on surfaces, and hence accelerated corrosion.

This work demonstrates that the potential advantages of biomass-coal cofiring can be achieved without risk to the boiler if judicious choices regarding fuel selection, boiler operation, and boiler design are made. Conversely, improper choices can lead to potential risk for the boiler and troublesome operation. The most attractive fuels are high-quality woods; increasingly careful attention to boiler operation and fuel selection are required with high-alkali, high-chlorine, high-ash, or high-nitrogen forms of biomass.

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